Integrity Service Excellence

A Systems Thinking Approach to Building and Updating C4ISR Architecture Views

William B. Carter

29 January 2003

U.S. AIR FORCE

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
29 JAN 2003		**00-00-2003 to 00-00-2003**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
A Systems THinking Approach to Building and Updating C4ISR Architecture Views	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **U.S. Air Force Academy,2354 Fairchild Drive,Colorado Springs,CO,80840**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**21**	

C4ISR Architecture View Update Process

U.S. AIR FORCE

PURPOSE

- Describe the outcomes of a systems thinking analysis to understand the dynamics of building and updating C4ISR architecture views
- Present a process model and checklist for required key information at each step in the model
- Identify critical success factors for life cycle architecture update mechanisms

U.S. AIR FORCE

Benefits of C4ISR System Architectures

- Picture of SPO's program objectives
- Program architecture integration and transition tool
- Support of DoD Acquisition Over Site

High Level Executive Usage

- Source of system requirements specification
- Source of system design specification
- Execution model for system architecture

Detailed Level Implementer Usage

U.S. AIR FORCE

Rationale for Documenting the Investigations in the Paper

- **C4ISR architecture views provide a method for IT programs to communicate**
  - **Who they are, what they do, and**
  - **How, in general, SPOs want to be viewed by other organizations**
- **High-level architectures support enterprise decision makers who might be unfamiliar with the technical details of a system**
  - **Understanding commonalities and inconsistencies between (a) merging systems, (b) systems on a collision course, and (c) major transitional stages in a single system's evolution**
- **Low-level architecture views, on the other hand, allow IT experts to identify, analyze, and specify potential and real integration issues**
  - **Provides comparable detailed structured archives that they can manipulate to characterize specific current architectural conflicts**
- **Within the limitations of time, funding, and political will, analyzing architecture views can identify future integration issues by executing detailed systematic comparative analyses**
- **Keeping C4ISR architecture views updated—and therefore an accurate living representations of a system architecture—is *the name of the game***

Examples of GCSS-AF SPO Usage of High Level Architecture Views

U.S. AIR FORCE

- **Executive level programmatic and technical interchanges**
- **Program funding negotiations**
- **Customer OutReach: over 600 programs and customer organizations**
- **DoD Acquisition Oversight**
  - **Clinger-Cohen Act Compliance**
  - **C4ISP Approvals**
  - **Certificate of Networthiness**

U.S. AIR FORCE

C4ISR Architecture Products Required for Acquisition

Architecture Products		COAC		Guidance		
		Domain	Acq Pgm	C4ISR Arch - Mandatory	C4ISP	ESC/CC
All Views Architecture						
AV-1	Overview & Summary Information	C	P	X	X	X
AV-2	Integrated Dictionary	A*	P	X	X	X
Operational Architecture						
OV-1	High Level Operational Concept Graphic	A*	P	X	X	X
OV-2	Operational Node Connectivity Description	A*	P	X	X	X
OV-3	Operational Information exchange Matrix	A*	P	X	X	X
OV-4	Command Relationships	A*				
OV-5	Activity Model	A	P	AFI, V	X	
OV-	Operational Activity Sequence (Rule Model)					
OV-	Operational Activity Sequence (State Transition)				O	
OV-	Operational Activity Sequence (Event Trace)	A	P		X	
OV-7	Logical Data Model	A	P	AFI	X	
Systems Architecture						
SV-1	System Interface Description	C	P	X	X	X
SV-2	System Communications Description	C	P		X	X
SV-3	Systems (N2) Matrix					
SV-4	Systems Functionality Description	C	P			X

A - AC2ISRC Responsibility, COAC Develop
A* - AC2ISRC Initial, COAC Further Development
C - Combat Operations Architecture Council Responsibility
P - Program Responsibility
X - Mandated Product
O - Optional
V - C4ISR Arch Framework Version 2.1
AFI - AFI 33-124 Required for Air Force Architectures
COAC - Combat Operations Architecture Council Sponsoring Programs

C4ISR Architecture Products Required for Acquisition (concluded)

U.S. AIR FORCE

Architectures Products (concluded)		COAC		Guidance		
		Domain	Acq Pgm	C4ISR Arch - Mandatory	C4ISP	ESC/CC
Systems Architecture (concluded)						
SV-8	System Evolution Description	C	P		O	X
SV-9	System Technology Forecast	C	P			X
SV-10a	System Activity Sequence & Timing description (Rule Model)					
SV-10b	System Activity Sequence & Timing description (State Transition)					
SV-10c	System Activity Sequence & Timing description (Event Trace)				O	
SV-11	Physical Data Model					
Technical Architecture						
TV-1	Technical Architecture Profile	C	P	X	X	X
TV-2	Standards Technology Forecast (TV-2)					

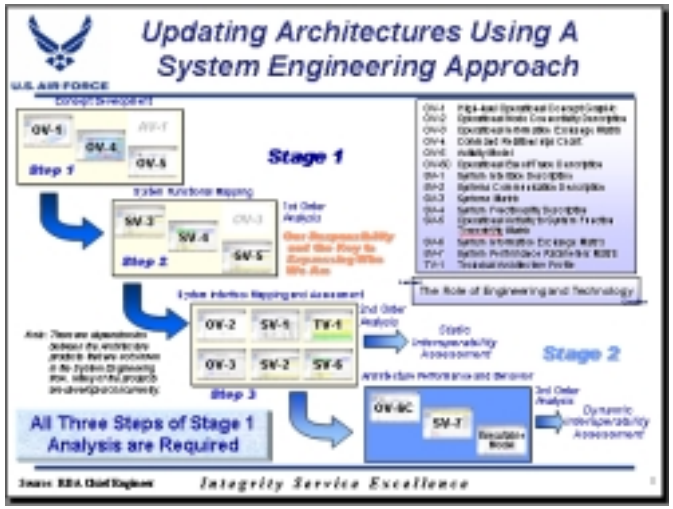
A - **AC2ISRC Responsibility, COAC Develop**
A* - **AC2ISRC Initial, COAC Further Development**
C - **Combat Operations Architecture Council Responsibility**
P - **Program Responsibility**
X - **Mandated Product**
O - **Optional**
V - **C4ISR Arch Framework Version 2.1**
AFI - **AFI 33-124 Required for Air Force Architectures**
COAC - **Combat Operations Architecture Council Sponsoring Programs**

U.S. AIR FORCE

Creating and Updating C4ISR Diagrams

Key to the Process: Architecture documentation is valid only if it kept up to date on the shelf

- **Re-use of work by Ellen Conway and the MITRE COAC on dynamic interoperability assessments of architectures**
  - **Two stages**
  - **Three step Stage 1 to assess completeness of architecture**



- **Added interrelationships of architecture views and data collection requirements for selected views**
- **Developed a static update process flow for Stage 1**

U.S. AIR FORCE

A Rapid Jog Through Some High Level GCSS-AF Architecture Examples

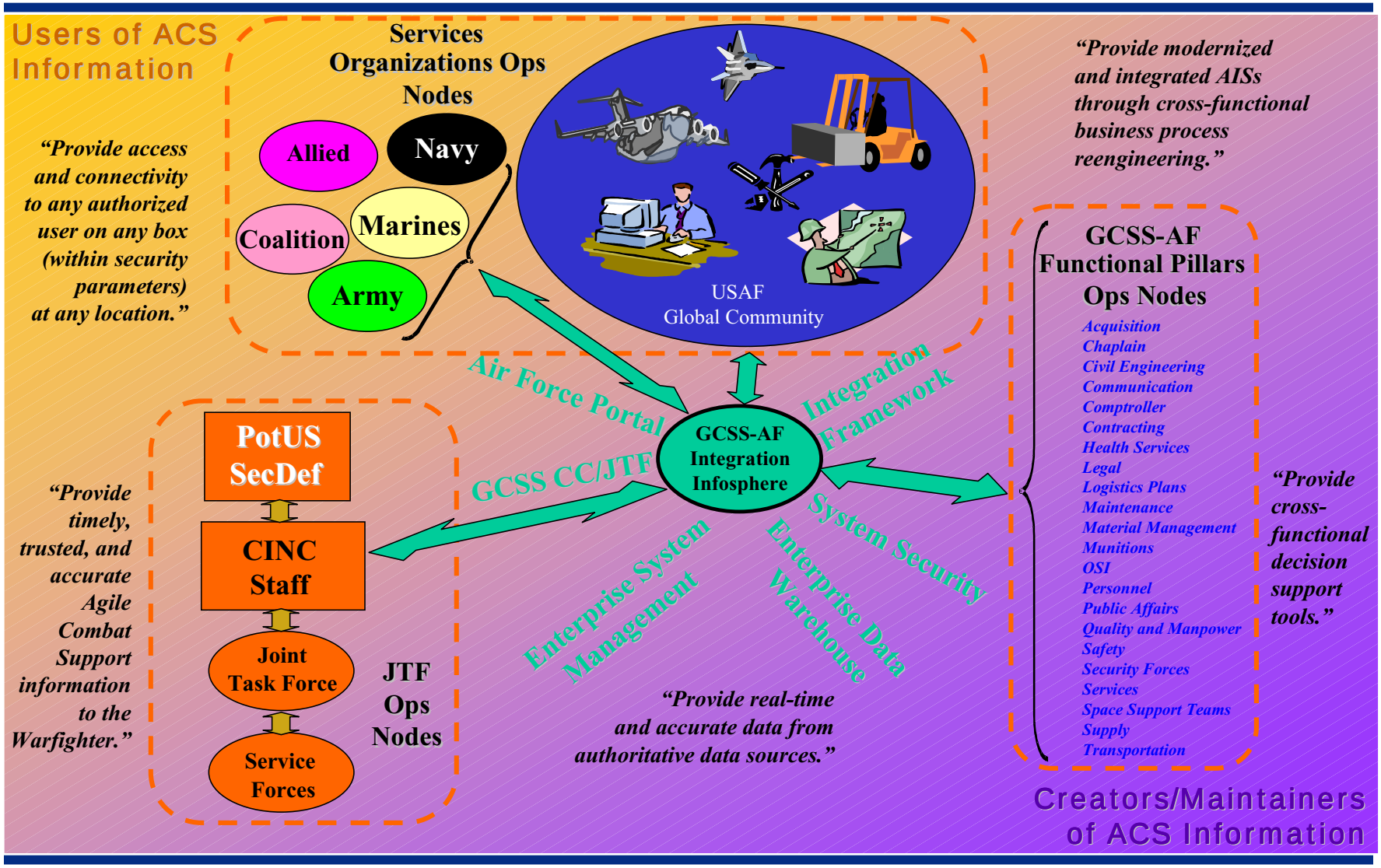
HIGH LEVEL EXECUTIVE VIEWS

- GCSS-AF High-Level Operational Concept Description (Operational View-1)
- GCSS-AF System Interface Description (System View-1)
- GCSS-AF System Communications Description (SV-2)
- GCSS-AF Systems Functionality Description (SV-4)
- GCSS-AF Operational Node Connectivity Description (OV-2)
- GCSS-AF Operational Node Connectivity Description (OV-2)
- GCSS-AF Systems^2 Matrix (SV-3)

DETAILED LEVEL IMPLEMENTER VIEW

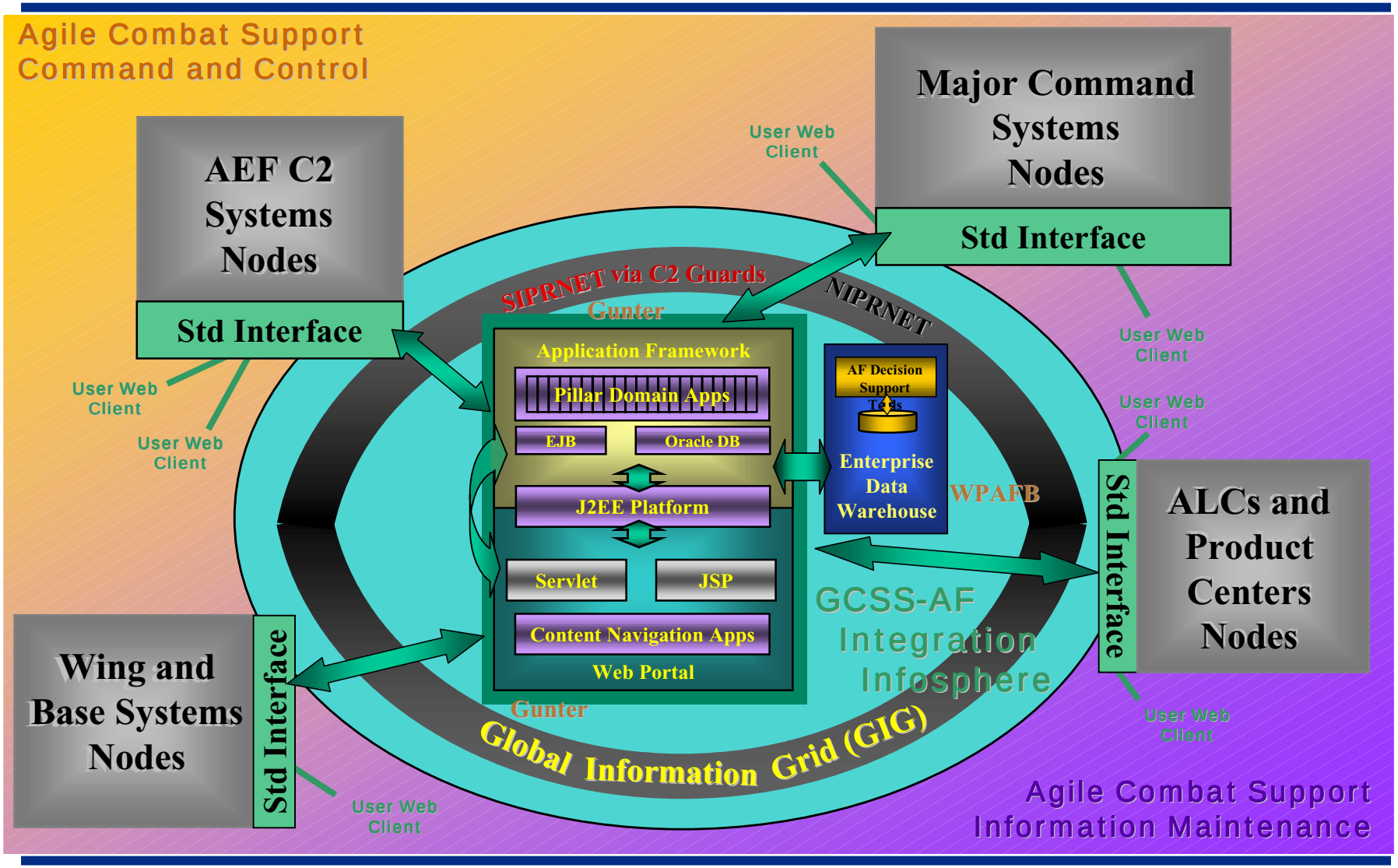
- Overview of GCSS-AF System Data Exchange Matrix (SV-6)

GCSS-AF High-Level Operational Concept Description (OV-1)



Source: ORD, 12/01; SPO

GCSS-AF System Interface Description (SV-1)

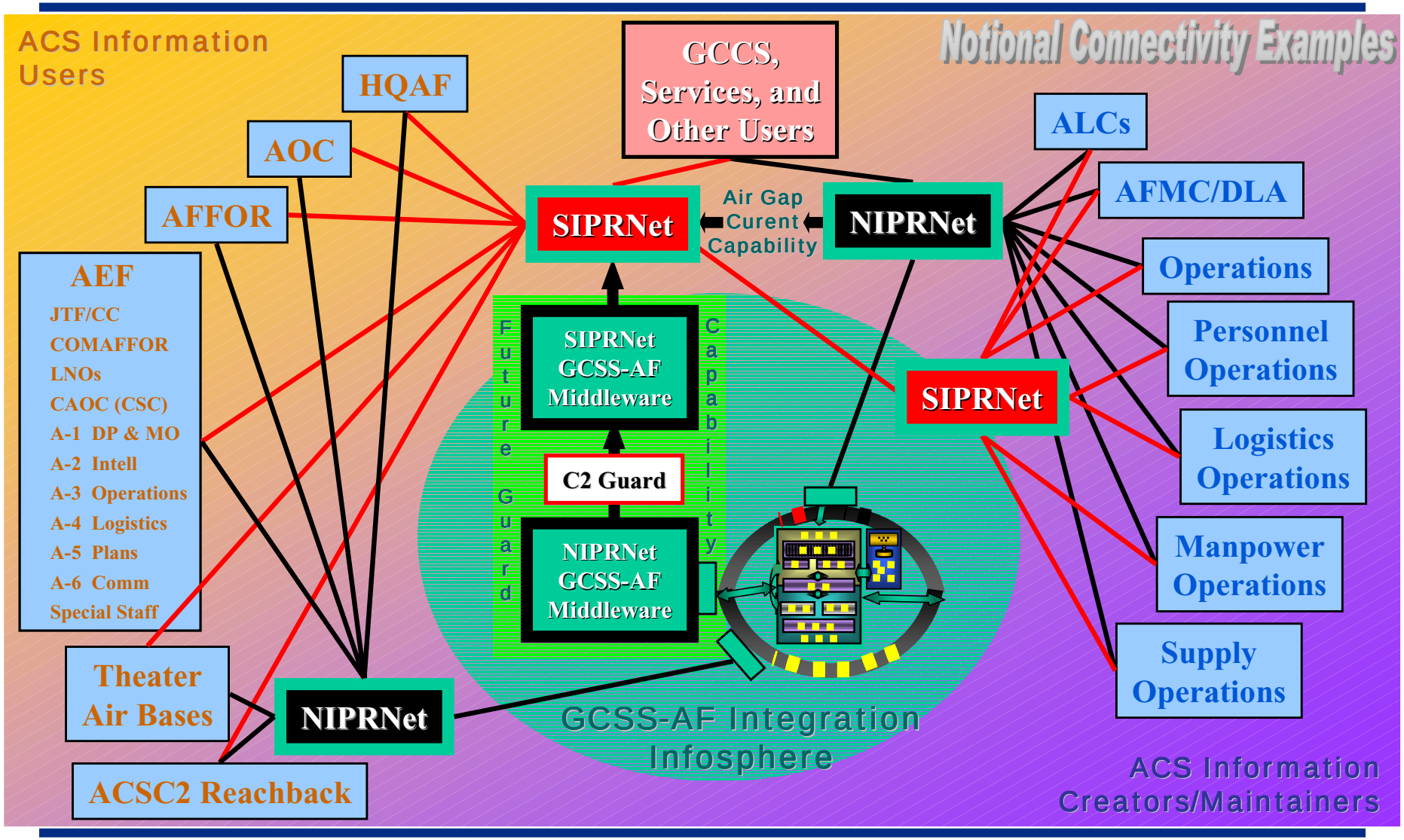


Source: SPO

Integrity Service Excellence

GCSS-AF System Comm Description (SV-2, NIPRNET to SIPRNET Connectivity)

U.S. AIR FORCE



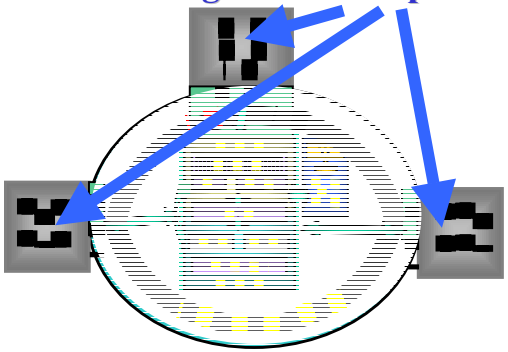
Source: GCSS-AF ORD, S PO

Integrity Service Excellence

GCSS-AF Systems Functionality Description (SV-4)

U.S. AIR FORCE

Warfighter ACS Systems Nodes Supported by GCSS-AF Integration Infosphere



ACS C2 Execution
- Forces Beddown
- Warfighter Requiremts Coordination
- Sortie Generation

ACS C2 Dynamic Planning

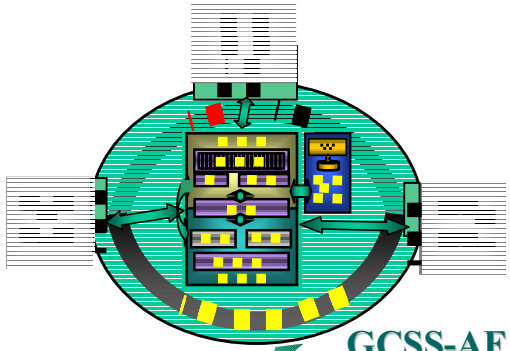
AEF ACS C2

Functional Pillars Information Flows (Documented by AIS SPOs)

Creation/Maintenance of Accurate Functional Data

Theater ACS C2

ACS C2 Reachback



GCSS-AF Integration Infosphere Supporting Warfighter ACS Systems Nodes

Integration Framework (IF) and Air Force Portal (AFP)

Enterprise Systems Management (ESM)

GCSS-AF Subsystem Information Flows (Documented by GCSS-AF SPO)

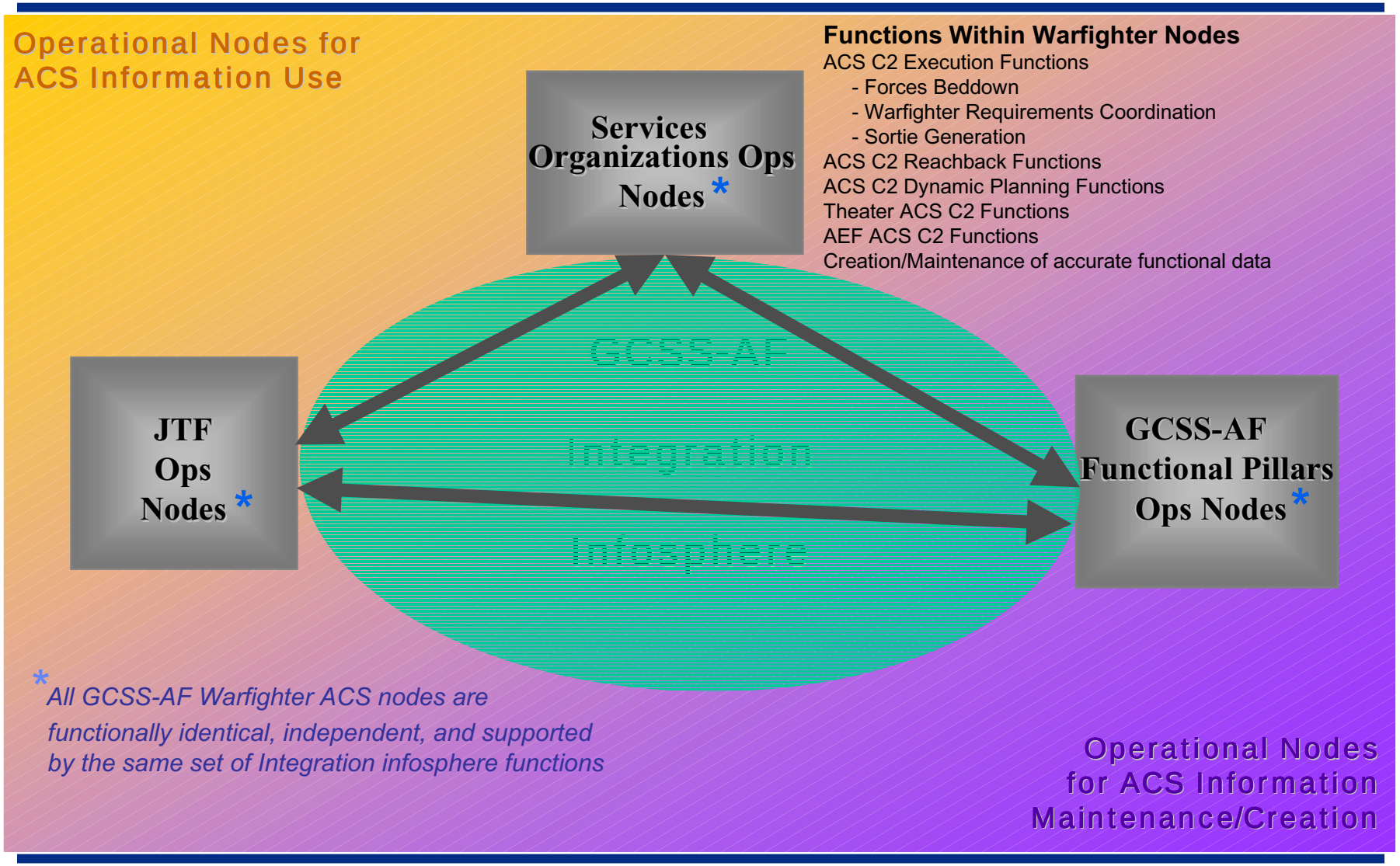
System Security

Enterprise Data Warehouse (EDW)

Source: ORD, 12/01

Integrity Service Excellence

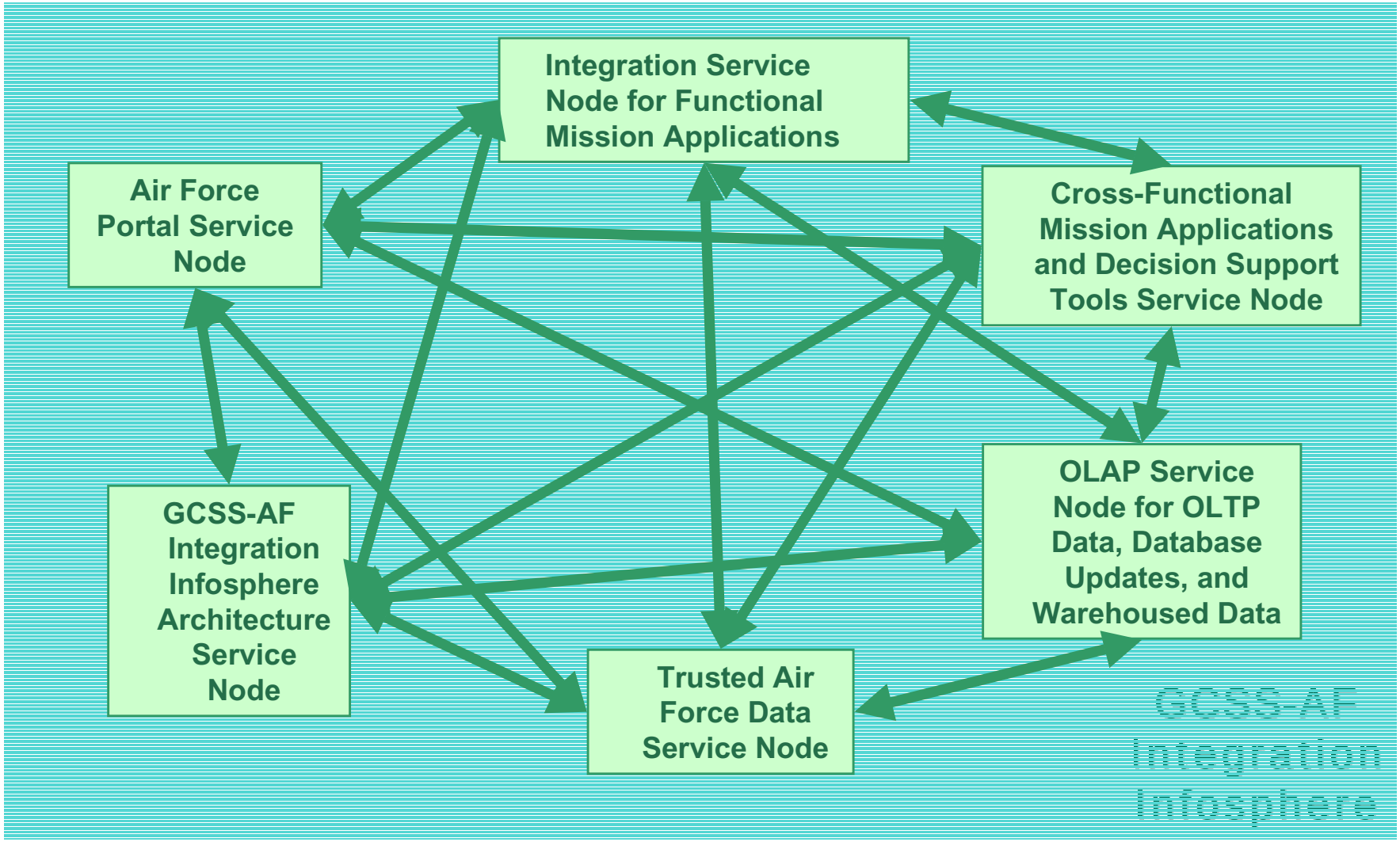
GCSS-AF Operational Node Connectivity Description (OV-2, ACS Warfighter)



Source: SPO

GCSS-AF Operational Node Connectivity Description (OV-2, Integration Infosphere)

U.S. AIR FORCE



Source: SPO

U.S. AIR FORCE

GCSS-AF Systems² Matrix (SV-3)

High-Level GCSS-AF Integration Infosphere System Components Matrix

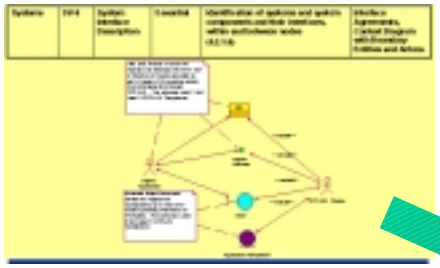
High-Level System Component	Integration Framework (IF) and AFP	System Security	Enterprise Systems Management (ESM)	Enterprise Data Warehouse (EDW)
Integration Framework (IF) and Air Force Portal (AFP)		x	x	Future
System Security	x		x	Future
Enterprise Systems Management (ESM)	x	x		Future
Enterprise Data Warehouse (EDW)	Future	Future	Future	

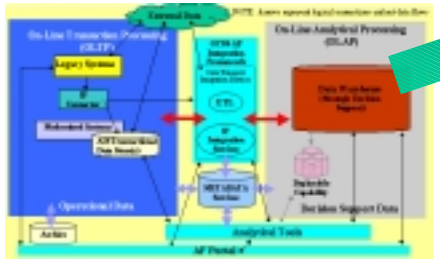
GCSS-AF Warfighter Operational Activity to System FunctionMappings
(To be documented by AIS SPOs)

Source: SPO

GCSS-AF System Data Exchange Matrix (SV-6, Integration Infosphere)

U.S. AIR FORCE





Mapping of Underlying Detailed System Data to the SV-6 Architecture View

C4ISR Template to Document As-Built Integration Infosphere System Information Exchange Data

Identifier/ Name of Operational Needline Supported (from OV-2)	Identifier/ Name of Operational Information Exchange Supported (from OV-3)	Identifier/ Name of System Data Exchange	Nature of Transaction						Data Source			Data Destination		
			Content	Size	Media	Format	Protocols Used	C4ISR Level Achievable	ID of Source System & System Element	Source System Function	Operational Node(s) Where Source System Resides	Identity of Receiving System Element	Receiving System Function	Operational Node(s) Where Receiving System Resides
1														
	e.g. 1-a													
2	e.g. 1-b													
	e.g. 1-n													
n														

CONTINUED

Identifier/ Name of Operational Needline Supported (from OV-2)	Identifier/ Name of Operational Information Exchange Supported (from OV-3)	Identifier/ Name of System Data Exchange	Requirements				Assurance Attributes								Data Exchange Occurs		
			Frequency	Timeliness	Throughput	Other	Classification/ Declassification Requirements	Crypto	Integrity Checks Required	Assured Authentication via Secret Key(s)	Physical	Security (passage, barriers, etc.)	Personnel Security	Where	Time	Policy/ Doctrine Constraints
1	e.g. 1-a															
	e.g. 1-b															
	e.g. 1-n															
2																
n																

Source: DoD Arch Framework v1.1

U.S. AIR FORCE

Objectives of the C4ISR Architecture View Update Process

- **Maintain a clean requirements specification (System Data Exchange Product View)**
  - **Describes, in tabular format, system functional data exchanges between systems within a node and across nodes**
  - **Keys system functional data exchanges back to the operational activity information exchange it helps to satisfy (i.e., system functions Ł an operational activity**
- **Need to support many-to-many linkages in <u>both</u> directions (i.e., ops activities Ł system functions)**

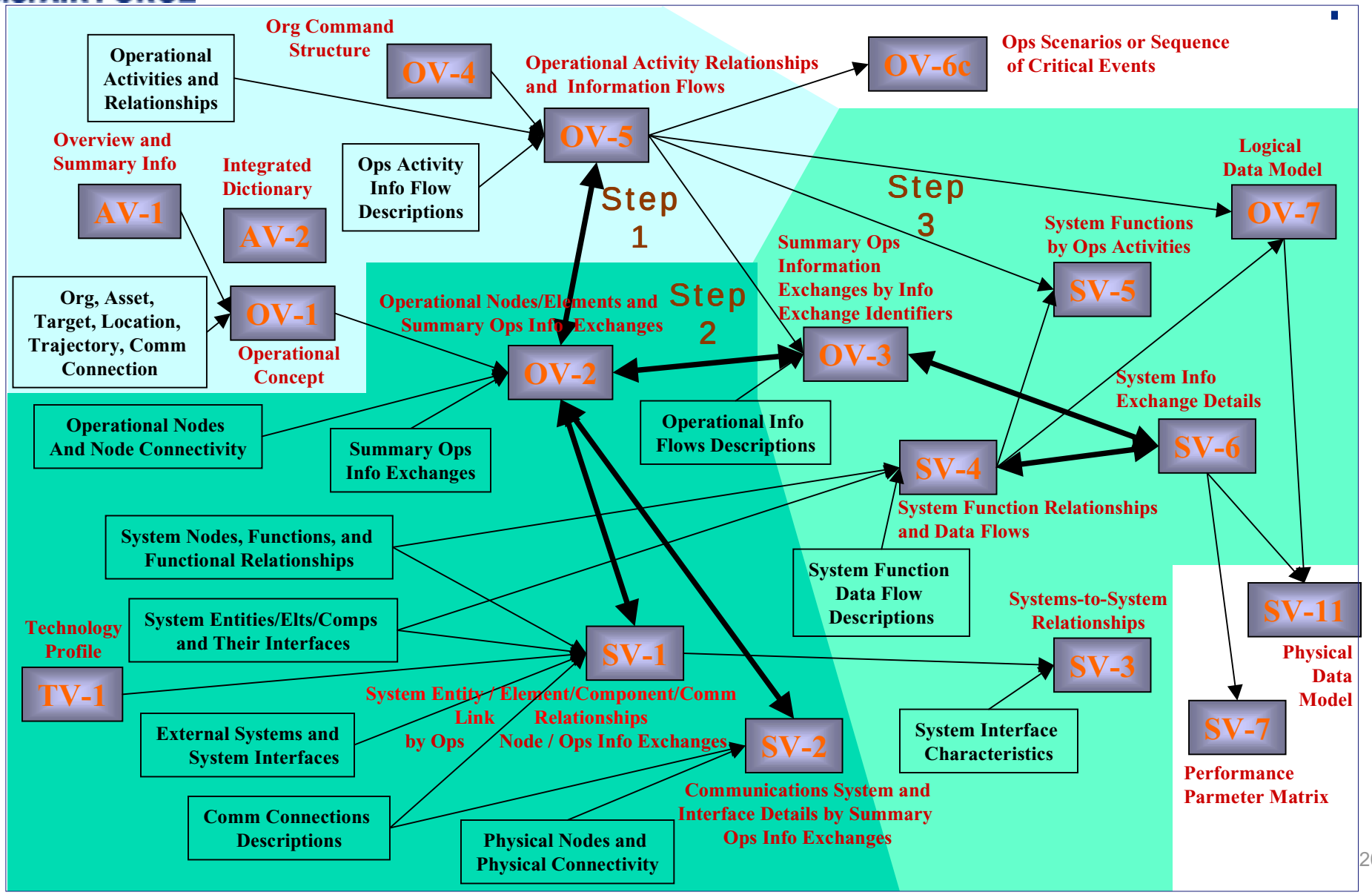
U.S. AIR FORCE

Sources of the Impact and Change on a System Architecture

- **Immaturity of the system architecture**
- **Generating the first instance (AV needed; high level data for OVs, SVs, and TVs to get started)**
- **Adding, deleting, swapping out technologies**
- **Adding, deleting, swapping out major system functions**
- **Adding, deleting, swapping out major operational activities**
- **Adding, deleting, swapping out both major operational activities and major system function at the same time**

Simplified C4ISR Architecture View Update Process

U.S. AIR FORCE



U.S. AIR FORCE

Insights on the Dynamics of the Update Process

- Critical Success Factors Identified by the Systems Thinking Analyses
  - Thick lines identify critical dynamic linkages
  - Maturity of the a general system architecture
  - Maturity of your architectural data and data collection process
  - Volatility of the As-Is or To-Be architecture
  - Completeness of your implementation plan for life cycle updates
- Eager to hear reviews of my paper at wbc@mitre.org